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Investigating understanding the nature of science

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ABSTRACT

The survey method was employed for investigating understanding nature of science (NOS) between general science education and science pre-service teachers. Independent t-test and two-way ANOVA were used for testing hypothesis. Results found that both of two programs rated understanding NOS ranges disagree and highly agree levels in different items. The item 'scientists work in their laboratory, even though social needs are not influence to scientists', disagree for general science education but agree for science program. The post-hoc test indicated that there were not differences by mean scale of two programs. There was no interaction between group and components of NOS. The post-hoc test also indicated that not found the differences in each component among scientific worldview, scientific inquiry, and scientific enterprises. However, three components of NOS must incorporate to teacher preparation program for making community of science and literate person as well as philosophy of science education.

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1. INTRODUCTION

Science is knowledge that has been developed by human creativity, acceptance useful knowledge to society, and products of knowledge and technology in the response patterns. These are the impetus and propulsion to science and development [1, 2]. It makes an important of curiosity in humans infinitely.

Also, science is a social process that society should continue some scientific paradigm shift, it may prove not to be in the social and cultural dimensions [3]. Teaching science is an important goal for developing the youth to know and understand the nature of science. Humans have learned things in nature, because human beings have complex brain structures. In nature, a fundamental cause of pursuing scientific development as instruments of cultural tools. It explains phenomena in the ways that science is accepted [4] by relying on the language of science, transmitted from the social science to the public which scientists use to describe the information about the natural knowledge that society can absorb and modify the direction for development [5].

Science corresponds to knowledge-based systems, mostly the natural phenomena explained. That is science concerns our lives and also education for all through science education, provide science in such suitable way by instructional strategies in school [6]. Now, we cannot deny science is an important culture in the modern world to improve the quality of life. Science teaching and learning must cultivate students insight and perspective that science is a way of life [7]. We should raise awareness to our young children and youth that science is under the rules of nature to live together with balances [8, 9]. Modern society should change the new view and understand the meaning of science is knowledge, creative and productive science drives innovation [10]. Understanding nature of science is the goal of science education, children should have it as well as necessary learning skills.

The American Association for the Advancement of Science (AAAS) [1] have offered substantive issues relevant to the nature of science by dividing into 3 components include the scientific worldview, scientific inquiry, and scientific enterprise. Scientific worldview is a concept regarding organized schemes of phenomena that occur in nature. If there is research carefully to make humans discover and understand it. A partial study of the universe, it can bring knowledge to deploy with the universe, almost the entire system. Knowledge gained from the study of the universe, it can be changed, because it is learned from observing and lead to the creation of a theory to explain the phenomenon. There is a possibility that a new phenomenon will not be explained by the original theory. Transformation of knowledge and therefore contribute to improving concepts rather than denied. Scientific inquiry is a quest for learning scientific approach or method that generates knowledge. The quest for learning must be based on testimony derived from observations and scientists will need to control the conditions. It happens according to conditions without depending on other conditions influences. But if the scientists can't control the conditions of what is studied. Scientists need to study phenomena in the following reference summary. The quest for learning requires both scientific reason and imagination in the creation hypothesis, as well as how to monitor an assumption will lead to links between the testimony and the evidence down the cause and effect principle conclusions. Scientific enterprise is social complexity, because science permeates life and scientific applications. Science is invited to educational system, opening knowledge and methods to teaching in educational institutions and agencies. Each agency has a role in the operation of the different scientific. Scientists, both as academics and members of a society troubled in society as part of the society. In addition science has been involving the participation of the public, scientists, scientific activities, scientists can assist the public in understanding the causes of natural disasters or damages arising from science and technology.

In considering the environment around us, and all are involved in relation to the nature of science. Science educators, therefore focuses on the importance of teaching, that is consistent with the recognition and understanding of the nature of science [8, 11-13]. The nature of science, it was aimed at understanding the characteristics of the scientific process and the factors that make development of science. Managing the teaching and learning of science that promotes a natural science should take into account the importance of the development of attitudes toward science. Students should have knowledge and skills, and creativity in the development of understanding natural setting [14]. If teachers have less understanding the nature of science, it connects to students' perception and understanding as well. Teachers should have understanding nature of science and promote it to their students by suitable learning atmosphere.

Pre-service teachers are key elements to scaffold students meet nature of science. If they have accurate concepts and understandings, they can help students to meet goal of science education. That is, nature of science is important for making being scientist in students' perception and behaviors. If they less or lack off nature of science, it may lead students ignore science and community of science. Teachers are key factors to invite nature of science to classroom and make citizens or community of science. So that, this study aims to investigate and compare understanding nature of science between general science education pre-service teachers and science pre-service teachers. The survey method is employed for investigating differences. The results will guide science educators to considerally designed curriculum and implement instructional practices in terms of promoting nature of science.

2. RESEARCH METHOD

2.1. Participants

In order to assess the three components nature of science, a survey methods and instrument to investigate nature of science was developed following the instrument development guidelines described by AAAS [1] for creating an affective NOS scale. The instrument was made 25 items were generated by a panel of experts. The 3 experts verified and provided valuable suggestion to the questionnaires. The validity or index of congruence was reported ranges between 0.67 and 1.00 for 25 items. It indicated that questionnaire can be used for data collection with participants. To complete the NOS components and questionnaires, the participants rated the extent to which each item belonged in the respective category. The resulting in NOS scale was administered to pre-service teachers from general science education program (science education) and teaching science and mathematics program (science) by using a 4-point Likert scale (1=Highly Disagree, 2=Disagree, 3=Agree, and 4=Highly Agree).

2.2. Data collection

The research employed survey method to collect NOS of all participants. The first semester of academic year 2019 from one university in the northeast of Thailand was representative study. They were introduced to nature of science by various kinds of subjects in program of study. Two cohorts, science pre-service teachers and general science education teachers enrolled in different course, but they have to express

NOS by themselves. All students rated their opinions to nature of science in freely by answering NOS questionnaires through Google form. Then, data were corrected in completeness before manipulating data by statistical package program.

2.3. Data analysis

Data were calculated by mean and standard deviation for considering criteria of pre-service teachers' understanding the nature of science. The mean score can be decided that ranges 1.00-1.50=Highly disagree, 1.51-2.50=Disagree, 2.51-3.50=Agree, and 3.51-4.00=Highly agree. Then, understanding the nature of science of two groups of pre-service teachers were tested the mean differences by independent t-test. The differences between group of pre-service teachers and components of NOS were tested by Two-way ANOVA. Findings were presented in quantitative explanation to seek the statistical differences. Mean and standard deviation were used for descriptive statistics and also two way ANOVA was employed to test hypothesis.

3. RESULTS AND DISCUSSION

Understanding nature of science between general science education and science pre-service teachers explored that both of two programs rated understanding NOS ranges disagree and highly agree levels in different items. The item "scientists use their knowledge to describe and predict phenomena based on evidences" general science education pre-service teachers rated in agree (M=3.44, SD=0.50), science pre-service teachers rated in highly agree (M=3.55, SD=0.51). In addition, general science education pre-service teachers rated in highly agree (M=3.55, SD=0.54 and 3.53, SD-054), science pre-service teachers rated in agree (M=3.41, SD=0.59 and M=3.45, SD= 051) for item "scientific knowledge will be reliable when evidences are enough" and "scientists must to publish of what they explore to public society" in the following. But the item "scientists work in their laboratory, even though social needs are not influence to scientists" general science education pre-service teachers rated in disagree (M=1.96, SD=0.64), science pre-service teachers rated in agree (M=2.36, SD=0.79). More details can be described in the Table 1.

For general science education and science pre-service teachers rated their understanding NOS, the items in disagree level were "scientists deny imagination and creative thinking to explore new knowledge", "scientific knowledge or explorations are products of scientists, needs of society and community culture are not related", "scientists work in their laboratory, even though social needs are not influence to scientists", "we use process of science for making a consideration of which picture in gallery is the best", "scientist works in lonely under setting laboratory, if many scientists may be difficult to conclude", "scientists do research by taking responsibility to benefits than those moral and ethics", "scientific knowledge comes from experiments only", "scientists employed only creative thinking for designing innovations and inventions", and "scientists are social partners, on behalf of expertise who understand and criticize on phenomena even though no more showing opinions and feelings".

The items in agree level were "scientists explore their knowledge through the same methods and explicit procedures", "personal opinions emerged from diversity of demographic, sex, beliefs, or previous experiences which not influence to working of scientists", "natural phenomena are often showed the same pattern and it can be understandable", "we are often remember in scientific law because it is accurate and proved in many times", "scientists try to explain and predict phenomena in accurately even though what they all explain will not be describable", "science and technology are same things", "science cannot explain about world and all about world, but it can predict what will be happened with the world", "science can describe concrete knowledge, natural phenomena, and other surroundings", and "there are some phenomena which we cannot investigate by scientific method".

The items in highly agree level "scientists will repeat their experiments to reduce some mistakes", "scientists aware and ignore bias that it will be appeared in the process of interpretation", "scientific knowledge can be changed, if additional evidences can explain much more than those prior knowledge", and "science and technology influence to society movements, and also society influence to development of science and technology. While the different rating items by general science education pre-service teachers made "scientists use their knowledge to describe and predict phenomena based on evidences" in agree level, but science pre-service teachers rated highly agree level. Also, "scientists must to publish of what they explore to public society" and "scientific knowledge will be reliable when evidences are enough" rate highly agree for general science education pre-service teachers, and rated agree for science pre-service teachers.

Table 1. Understanding NOS of pre-service teachers

Item	General science education			Science		
	M	SD	understanding NOS	M	SD	understanding NOS
Science can describe concrete knowledge, natural phenomena, and other surroundings	3.38	0.53	Agree	3.32	0.65	Agree
Natural phenomena are often showed the same pattern and it can be understandable	2.56	0.76	Agree	2.73	0.83	Agree
Scientific knowledge can be changed, if additional evidences can explain much more than those prior knowledge	3.69	0.47	Highly Agree	3.64	0.49	Highly Agree
We are often remember in scientific law because it is accurate and proved in many times	2.60	0.85	Agree	2.95	0.65	Agree
We use process of science for making a consideration of which picture in gallery is the best	1.98	0.80	Disagree	1.86	0.64	Disagree
There are some phenomena which we cannot investigate by scientific method	3.42	0.60	Agree	3.36	0.73	Agree
Scientists try to explain and predict phenomena in accurately even though what they all explain will not be describable	2.96	0.61	Agree	3.45	0.51	Agree
Scientists use their knowledge to describe and predict phenomena based on evidences	3.44	0.50	Agree	3.55	0.51	Highly Agree
Scientific knowledge will be reliable when evidences are enough	3.55	0.54	Highly Agree	3.41	0.59	Agree
Scientists deny imagination and creative thinking to explore new knowledge	1.78	0.69	Disagree	2.05	0.65	Disagree
Scientists employed only creative thinking for designing innovations and inventions	2.15	0.52	Disagree	2.45	0.86	Disagree
Science cannot explain about world and all about world, but it can predict what will be happened with the world	3.00	0.75	Agree	3.00	0.69	Agree
Scientists will repeat their experiments to reduce some mistakes	3.60	0.63	Highly Agree	3.55	0.74	Highly Agree
Scientists aware and ignore bias that it will be appeared in the process of interpretation	3.67	0.58	Highly Agree	3.59	0.50	Highly Agree
Personal opinions emerged from diversity of demographic, sex, beliefs, or previous experiences which not influence to working of scientists	2.51	0.81	Agree	2.82	0.73	Agree
Scientists explore their knowledge through the same methods and explicit procedures	2.47	0.77	Agree	2.86	0.77	Agree
Scientific knowledge comes from experiments only	2.13	0.75	Disagree	2.36	0.79	Disagree
Scientific knowledge or explorations are products of scientists, needs of society and community culture are not related	1.78	0.63	Disagree	2.00	0.44	Disagree
Scientist works in lonely under setting laboratory, if many scientists may be difficult to conclude	2.00	0.67	Disagree	2.32	0.57	Disagree
Scientists are social partners, on behalf of expertise who understand and criticize on phenomena even though no more showing opinions and feelings	2.36	0.68	Disagree	2.45	0.86	Disagree
Scientists must to publish of what they explore to public society	3.53	0.54	Highly Agree	3.45	0.51	Agree
Scientists do research by taking responsibility to benefits than those moral and ethics	2.05	0.85	Disagree	2.45	1.01	Disagree
Science and technology are same things	2.98	0.62	Agree	3.14	0.64	Agree
Science and technology influence to society movements, and also society influence to development of science and technology	3.49	0.54	Agree	3.36	0.49	Agree
Scientists work in their laboratory, even though social needs are not influence to scientists	1.96	0.64	Disagree	2.36	0.79	Agree

To make sure, comparing understanding nature of science between two groups of pre-service teachers' independent t-test was used. Two groups of program of study had no differences of the understanding nature of science. Information can be shown in Table 2 for explaining statistical report.

Table 2. Comparing understanding nature of science between two groups

Program	n	M	SD	df	t	p
General science education	55	2.76	0.68	54	0.78	0.438
Science	23	2.90	0.56	22		

Understanding NOS of two groups by testing the mean scale, it found that there were not differences. General science education pre-service teachers had mean scale slightly lower than science pre-service teachers. To compare understanding NOS by variance analysis between group of respondents and components of NOS, Two way ANOVA was employed. The result indicated that there was no interaction between group and component at .05 level of statistical testing. Variance test can be shown in Table 3.

Table 3. Comparing the difference scales between group and component

Source	Type III Sum of Squares	df	Mean square	F	p
Group	.185	1	.185	.472	.496
Components	1.202	2	.601	1.528	.228
Group * Components	.039	2	.019	.049	.952
Error	17.304	44	.393		

Understanding NOS of two groups by testing variance between group of study and components of NOS found that there were not differences. Then, post-hoc test was employed to investigate pair differences between among components. The equal variance not assumed by Dunnett's T3 was used. Statistical report was not found the differences in each component among scientific worldview, scientific inquiry, and scientific enterprises.

The results showed that two groups of pre-service teachers have understanding NOS in the slightly similarity perception. They disagreed with scientists deny imagination and creative thinking to explore new knowledge; scientific knowledge or explorations are products of scientists, needs of society and community culture are not related; scientists work in their laboratory, even though social needs are not influence to scientists; we use process of science for making a consideration of which picture in gallery is the best; scientist works in lonely under setting laboratory, if many scientists may be difficult to conclude; scientists do research by taking responsibility to benefits than those moral and ethics- that are nature of science through scientific world view and scientific inquiry. That is, the two prongs of objectivist and subjectivist concepts lead understanding nature of science to the world [15-19]. However, some items that they rated disagree- scientific knowledge comes from experiments only; scientists employed only creative thinking for designing innovations and inventions; and scientists are social partners, on behalf of expertise who understand and criticize on phenomena even though no more showing opinions and feelings- it seems misconception about nature of science. These are important issues for teacher development in science education, especially curriculum and instructional strategies must be integrated by suitable ways [8, 20-22].

The perception in agree about understanding nature of science - scientists explore their knowledge through the same methods and explicit procedures; personal opinions emerged from diversity of demographic, sex, beliefs, or previous experiences which not influence to working of scientists; natural phenomena are often showed the same pattern and it can be understandable; we are often remember in scientific law because it is accurate and proved in many times; scientists try to explain and predict phenomena in accurately even though what they all explain will not be describable; science and technology are same things; science cannot explain about world and all about world, but it can predict what will be happened with the world; science can describe concrete knowledge, natural phenomena, and other surroundings; and there are some phenomena which we cannot investigate by scientific method- that are mostly in scientific inquiry and scientific enterprise components. They have concepts nature of science to meet the goal of science education [23-26].

Highly agree to understanding nature of science that they have - scientists will repeat their experiments to reduce some mistakes; scientists aware and ignore bias that it will be appeared in the process of interpretation; scientific knowledge can be changed, if additional evidences can explain much more than those prior knowledge; and science and technology influence to society movements, and also society influence to development of science and technology – it helps them to implement nature of science into curriculum and instruction as well as they perceived. However, school practicum should allow them to implement technology, pedagogy, and scientific content as well as nature of science appearance. While the items between general science education and science pre-service teachers rated ranges agree and highly agree but different level- scientists use their knowledge to describe and predict phenomena based on evidences, scientists must to publish of what they explore to public society and scientific knowledge will be reliable when evidences are enough- that is, they understood nature of science, but seems to be different concentrated [27-30].

Additionally, the comparison understanding nature of science between two groups of pre-service teachers showed that they have no differences. Even though general science education pre-service teachers have mean scale slightly lower than science pre-service teachers. Also, variance analysis between group of

respondents and components of NOS, there is no interaction between group and component. Statistical test is not found the differences in each component among scientific worldview, scientific inquiry, and scientific enterprises. It can be discussed that two programs of study can promote nature of science. They learn by different program, but it can make them to meet the goals of science education. However, the report needs more study in the teacher professionalism, pedagogical practices, and classroom management. The relationship between nature of science and other expectations in teacher preparation program by different methods need to be implemented [31-33].

4. CONCLUSION

Pre-service teachers from two programs have understanding NOS ranges disagree and highly agree levels in different items. There are not differences by mean scale of two programs, and no interaction between group and components of NOS. But it is very surprise in the last item general science education rated their understanding of NOS by *disagree* with 'scientists work in their laboratory, even though social needs are not influence to scientists', but science program *agree* as it happen. This finding need to make students more understanding and make them to have less understanding through teaching methods or appropriate instructional practices. The post-hoc test also indicated that not found the differences in each component among scientific worldview, scientific inquiry, and scientific enterprises. However, three components of NOS to incorporate to teacher preparation program for preparing teacher educators and also making community of science, literate person, knowledge-based society, and science for all as well as philosophy of science education.

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